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Fig. 11. White oaks *(Quercus alba)* in virgin forest, central Indiana.

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White Oaks of the Virgin Forest

Of the incomparable virgin forests that once stretched virtually unbroken from the central Mississippi Valley to the Atlantic, only here and there a fragment remains. Even Pennsylvania, its name notwithstanding, presently has only a pitiably small remnant—some 7000 acres in the aggregate—of the original forest that once covered its nearly 29 million acres.

To the pioneer settler the trees were giant weeds standing in the way of agricultural pursuits. Markets for lumber in this vast area, except near population centers and ports, were in the main absent, and home consumption (fuel, buildings, fences, etc.) utilized but a small fraction of what was cut down in clearing operations. The rest—untold billions of board feet of the choicest wood—was destroyed.

As the country developed so did markets for lumber. Timber became a source of revenue, powerfully increasing the pressure on this matches primeval resource so long considered inexhaustible. How great this economic pressure has now become the frontispiece (Fig. 11) will help us to comprehend. A single virgin white oak, like those pictured on the cover and only a stone's throw from them, last summer sold for $500 on the stump! With such returns, only those of the few remaining primeval vestiges as are acquired by responsible public agencies and administered as unexploited preserves are likely long to survive.

The photograph reproduced on the cover was taken nearly a half century ago in a 160-acre tract of magnificent virgin hardwood timber some 11 miles southeast of Indianapolis near the village of Julietta, in central Indiana. In the rich soils of the lower Ohio River drainage basin many of our hardwood species grew to their maximum size. The Julietta woods, which lies in this drainage area, was a worthy sample and reminder of the sylvan grandeur that once stretched over vast areas. It is regrettable that the past tense must be used. Though the tract remains as woodland, its great trees were marketed some years after the photograph was taken. Fortunately, in a smaller woods immediately adjoining, at least twenty five magnificent white oaks of the virgin forest still remain. It was a declining member of this venerable company that recently sold for $500.

With the great oaks, including the very ones in our photograph, was fittingly associated something else—a large colony of Great Blue Herrons with their huge brush pile-like nests in the very tops of the lofty crowns. When the great oaks went, so did the herrons. We are informed that herrons are currently nesting in the remaining virgin white oaks of the adjoining tract. May their homes long remain undisturbed.

J. R. SCHRAMM

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DAVIDIA IN THE PHILADELPHIA REGION

Davidia, or the Dove Tree, is one of the most famous trees introduced into western gardens from the mountain fastnesses of central and southwestern China during the beginning of the century. A rare and curious tree, its introduction and subsequent flowering in cultivation caused great excitement in the horticultural world. As a phylogenetically distinct stock, it is also of great interest to the botanist.

This remarkable tree was first discovered in Mupin, western Szechuan, by the famous French missionary and naturalist Abbé Armand David, in 1869. It was described as *Davidia involucrata* by Baillon in 1871, the generic name fittingly dedicated to the discoverer. A variety of this species, *Davidia involucrata* var. *vilmoriniana* Hemsley, was first collected in Wushan, western Szechuan, by another famous collector, Augustine Henry, in 1888. Subsequently Peré Farges discovered it also in northeastern Szechuan and sent seeds to Maurice de Vilmorin in France, who succeeded in raising one plant from the seeds, the first plant of this species raised from seed in cultivation.

Davidia is a medium-sized tree with spreading branches and large ovate serrate leaves resembling somewhat those of the linden tree. The inflorescences are pendulous, produced on short, lateral spur-like branches. These consist of numerous tiny naked 1- to several-stamened male flowers and one perfect (1 to several stamens and 1 pistil) flower laterally placed on the receptacle. The dome-shaped receptacle is subtended by two unequal bracts, the larger attaining a length of six and a half inches and the smaller about half as long. The bracts become snowy-white at their prime. The tree when in full bloom, with the large conspicuous bracts, is a rare sight. These pure white bracts resemble large white wings, resting or fluttering among the branches in the breeze, hence the name Dove Tree.

Fig. 12. Flowering branch from large Dove Tree *(Davidia involucrata* var. *vilmoriniana)* at "Crosswicks" near Jenkintown, Pennsylvania.

The variety *vilmoriniana* is very similar to the species and, except when very young, can be distinguished by its more glabrous leaves. In

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the juvenile stage, the young shoots are dull gray or slightly purplish in the variety and dark red in the typical form of the species. It is this variety that is found occasionally in the Philadelphia region and in northeastern United States. The typical form, apparently less hardy, rarely is encountered in this area.

The famous collector E. H. Wilson first went to China in 1899-1901 for the English firm Veitch with the principal object of securing seeds of this remarkable tree, particularly the plant which later was called variety *vilmoriniana*. Wilson secured and introduced a quantity of seed which produced some thirteen thousand plants. These were widely distributed in Europe and America. His subsequent trips in 1903-04 brought back seeds of the typical form of the species.

Many of Wilson's early introductions were planted in American gardens. In northeastern United States the tree is subject to killing back to the ground in hard winters, but is often able to send out new vigorous sprouts afterwards. After attaining some size these sprouts may bear blooms, but frequent killing back makes flowering a rare event. Only very infrequently is a tree able to attain any considerable size in this region and flower profusely.

Fig. 13. Lower part of large Dove Tree *(Davidia involucrata* var. *vilmoriniana)* at "Crosswicks" near Jenkintown, Pennsylvania.

On the grounds of the Morris Arboretum there are two trees of *Davidia involucrata* var. *vilmoriniana,* one planted near the edge of a pond and the second on a slope. The latter was received in 1949 through the Arboretum of the Barnes Foundation at Merion, Pennsylvania, where Davidia is grown successfully. The other tree was planted many years ago, and is apparently a plant from Wilson's earliest introductions. It flowered in the twenties but frost-killed to the ground in the severe winter of 1933-34. The following summer vigorous shoots developed from the stump, of which one persists. Both these trees flowered in early May, 1953, but the blooms were few in number, sterile (lacking perfect flower), and of small size. Also, the bracts appeared dull white and the entire inflorescences dropped off early.

Recently there came to our notice a remarkable specimen of the Dove Tree, also of the variety *vilmoriniana,* near Jenkintown, Pennsylvania, at the outskirts of Philadelphia. Located on the former estate, "Crosswicks," of Clement B. Newbold, at one corner of a formal garden now reverted to a dense thicket of shrubs and vines, the tree is of remarkable size and in excellent health, though it has been much neglected for years. In May, 1953, it was loaded with thousands of large, fully developed snowy-white "blossoms" (Fig. 12).

The height of the tree is fully 32 feet. The main trunk, which many years ago was apparently frost-killed to a few feet above ground, measures 5 feet 7 inches in circumference. Sprouting out again, it now has two main vertical branches 3 feet 7 inches and 3 feet 4 inches in circumference respectively at breast height. These two branches in turn were winter-killed some years ago to about 12 feet from the ground, the surviving bases suffering bark injury on the south side for nearly their entire length. Subsequently the two branches produced numerous vigorous shoots which form the present luxurious crown about 30 feet in diameter. There are also a few young sprouts arising from near the ground level. The lower part of the tree appears in Fig. 13.

This tree, as far as can be ascertained, was planted in the early 1900's from Wilson's first introductions, and is thus of the same age as the older one at the Morris Arboretum. Around 1925 the flowering of these two trees attracted considerable attention locally.

In May, 1953, this large "Crosswicks" tree flowered in great profusion. The bracts were of large size and of dazzling whiteness. The inflorescences, nearly every one of which bore among the staminate flowers the single perfect flower normal for Davidia, did not fall off as did those on the Arboretum trees. The bracts were not only larger and whiter but all were strictly entire. On the other hand, in the inflorescences on the Arboretum trees the margins of the bracts were serrate as in the foliage leaves.

The close relationship between the bracts and the foliage leaves is also indicated by other phenomena observed in this larger tree. Some of the leaves bore large elongated tips of snowy white color as in the bracts. Normally the bracts are sessile whereas the leaves are long-petiolate. On one floral branch there were two inflorescences instead of the usual one, with 2 bracts in one and 4 in the other. At the middle of the peduncle there was an additional very large bract which was white and entire but long-petiolate like a leaf. Other floral anomalies included 3 or 4 bracts per inflorescence instead of the usual 2, and the presence of 2 perfect flowers on a single receptacle instead of one.

On this larger tree, as well as on the other smaller trees observed, there occurred some partially discolored leaves which were at the same time sparsely-serrate or nearly entire. These leaves were nearly always the uppermost ones of the short branch bearing them. Blanching always occurred at the margin or in the outer part of the leaves, varying in shade from creamy white to light green. All these represent transitional stages between foliage leaves and bracts.

Also at Crosswicks there is a second Dove Tree but of much smaller size. It is apparently of the same age as the larger specimen, but the original trunk was evidently frost-killed to the ground years ago. At present the plant consists merely of some 5 or 6 vigorous shoots. These also bore some flowers in 1953 but the bracts were small, often with teeth, and all the inflorescences lacked perfect flowers and were shed immediately after flowering, as was the case in the two plants at the Morris Arboretum.

The larger Crosswicks tree bore quantities of well developed fruits in 1953. Unfortunately, nearly all were devoured or damaged by squirrels before fully ripened.

Wilson, studying the tree in the wild in China, records the maximum height found as 65 feet and the greatest trunk circumference as 6½ feet. The larger Crosswicks tree, which has a trunk circumference of 5 feet 7 inches, is thus only 11 inches below the maximum found by Wilson in its native habitat. In height it is about half the maximum noted by Wilson in China. But for the major killing back by severe cold on two occasions (Fig. 13) the tree now would surely be substantially taller — perhaps even rivalling the maximum observed by Wilson in its Oriental home.

However this may be, there can be no doubt that in the company of Davidias existing in the Philadelphia area the Crosswicks tree must be considered a venerable and distinguished member. It has been through battles with its antagonist—extreme cold. Though bruised, it has rallied each time and is facing the future in a reassuring state of health and vigor. Further setbacks may be in store for it. But for a half century it has not merely survived but responded with vigorous rejuvenation after each buffeting. There is thus every reason to believe that this specimen is biologically equipped to hold its own in our climate, certainly in its present location, and suffer only temporary setbacks in the severest winters which the Philadelphia area is likely to experience.

One wishes that this little account might end on this happy note; unfortunately it must close on one of apprehension. This exquisite rarity is in danger. The Crosswicks acres are in the midst of an extensive housing development. The threat of destruction is imminent. Some way should and, it would seem, must be found to preserve this remarkable tree. The immediate community, the Philadelphia area, and the development itself will be enriched thereby.

HUI-LIN LI
J. R. SCHRAMM

THE CHINESE TULIPTREE (Liriodendron chinense) IN NORTHEASTERN UNITED STATES

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There are two species of tuliptree, the American (*Liriodendron tulipifera* L.) and the Chinese (*L. chinense* [Hemsl.] Sarg.). The first is a large and important timber tree widely distributed in eastern North America, growing to a height of 150 feet. The Chinese tree is a small (60 feet), relatively unimportant forest tree in parts of western Hupeh and northern Kiangsi in central China.

The botanical history of the Chinese species is interesting (Wilson, 1905). It was first collected in 1873 at Lushan, near Kiukiang in northern Kiangsi, by the British medical missionary Shearer. Moore (1875) tentatively identified it as a new species in 1875, but it was not named. The discovery in a remote part of the world of a tree belonging to a genus hitherto considered monotypic and endemic to America was so astonishing that many believed its occurrence in China probably was to be explained as an introduction from the New World. A little later Maries collected flowers in the Lushan Mountains; and Hemsley named the tree *Liriodendron tulipifera* L. var. ? *chinense* Hemsl. (Forbes & Hemsley 1886). Only then was it certain that the tree was not a recent introduction from America.

A little more material was collected by Henry and Wilson in western Hupeh, and in 1903 Sargent (1903) gave the tree a species name of its own, only 2 weeks before Hemsley likewise raised it to specific rank (Hemsley, 1903). Since then other taxonomists (Wilson, 1905; Elwes and Henry, 1911; Bean, 1919) have upheld Sargent's species. And to the smaller flower and fruit size that Sargent considered the only distinctive characteristics, they added deeper leaf-lobing, smaller stature, and bushier form as distinguishing features.

The tree was first introduced into England and North America in 1901 (Wilson, 1905) as a result of Wilson's collecting in western Hupeh. As far as known there is only one living specimen in the United States from this introduction —a 30-foot tree growing in a protected location in the Brooklyn Botanic Garden. Even to the trained observer it appears much like a poorly growing specimen of the American species. The tree flowers occasionally—not every year as does the American tree.

In 1948 a new introduction was made from Lushan Botanic Garden through A. G. Johnson of the Arnold Aboretum. Seed from this collection (Northeastern Forest Experiment Station No. NEG 462) was obtained for testing by the Morris Arboretum. The seed germinated in 1949, and seedlings were grown in the Morris Arboretum's experimental nursery in comparison with native tuliptrees of local origin.

Up until the end of the second year the two species were distinguishable only by slight differences in their leaves. By the end of the fifth year, however, the Chinese trees were easily recognized by their repeated dieback—usually to the ground. This was probably due to winter cold, although it may have been accentuated by scale (*Toumeyella liriodendri*) and fungus attack. *Phomopsis* fruiting bodies were present on the dead twigs (Dr. Alma Waterman, personal communication). On the native species growing in the nursery neither pest caused appreciable damage.

Growth vigor of the American and Chinese nursery stock at the Morris Arboretum is compared in the following tabulation:

Species	Average height		Leaves per tree, fifth year
	Second year	Fifth year	
	Cm.	*Cm.*	*No.*
Chinese	64	65	20
American	54	318	305

To study the taxonomic characters of the two species, the largest leaf was collected from each of 13 Chinese and 6 American trees, all 5 years old. The two species compared as follows:

Species	Length of leaf blade	Blade length	Petiole length	Distances between sinuses
		Blade width	Blade length	Blade width
	Cm.	*Ratio*	*Ratio*	*Ratio*
Chin.	9.4	0.75	0.80	0.33
Amer.	11.5	.77	.76	.48

The small size of the Chinese leaves was due mostly to the poor vigor of the trees. Of the quantitative leaf differences, only relative depth of sinuses was significant. Several qualitative differences were also noted: The branchlets of the Chinese trees were grayish, with more lenticels; the leaves were thinner, easier to dry, less glossy, and purplish in late summer, turning yellow in the fall. The branchlets of the American trees were reddish and the leaves had a reddish autumn color.

Of all the vegetative differences noted, only the dieback and the relative depth of sinuses were sufficiently pronounced to enable one to identify a Chinese tree with certainty if found without a label in a native woodland.

A 2n chromosome count of ca. 38 made on aceto-carmine root tip smears of the Chinese plants agrees with the number reported for the American species (Whitaker, 1933).

Some of this same stock (from the 1948 seed from Lushan Botanic Garden) was outplanted at three different locations: Beltsville, Maryland; Philadelphia, Pennsylvania; and Williamstown, Massachusetts. The planted trees resemble those remaining in the nursery save that mortality has been higher. Of these outplanted trees, 1 of 18 survives at Beltsville, 3 of 11 at Philadelphia, and 2 of 3 at Williamstown. The trees at Williamstown have suffered only winter injury, and are the healthiest of the lot. At Beltsville 41 of 48 American tuliptrees planted at the same time survive and are healthy.

In view of our nearly complete failure with the Lushan trees and the doubtful success of the Brooklyn Hupeh tree, there seems little hope of utilizing the Chinese tuliptree in the Northeastern United States as a species; possibly it will be useful as a parent in hybrids.

But perhaps the American species would be of value in China. It is generally a better tree and seems more adaptable. It is grown to some extent in northeastern United States and in Japan, and is quite successful in arboreta in the milder portions of northern and central Europe.

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A REEXAMINATION OF PLANT LABEL PROBLEMS, WITH SOME NEW DESIGNS

J. R. SCHRAMM

For the experimenter, propagator, nurseryman, etc., for whom labels serve usually as short-time on-the-spot records of plants in the greenhouse, frames, nursery, or field, existing types fulfill all essential needs. On the other hand, for permanent plant collections serving public educational objectives, labeling presents special problems not all of which have been satisfactorily resolved. Faced some years ago with the task of relabeling many plants, especially at the Morris Arboretum, the matter was reexamined with some care with the result that a series of labels was designed and fabricated. Large numbers of these have now been in use for from eight to fifteen years—long enough to assess their performance and render a report. In doing so no claim is made that all the problems have been solved. It is hoped, however, that a modest contribution has been made toward the solution of at least some of them.

It probably is not difficult to reach substantial agreement on the attributes the ideal label should have. Doubtless these would be something as follows: (1) Visibility; (2) legibility; (3) permanence; (4) absence of injurious effects on the plants; (5) low initial cost; (6) low maintenance cost; (7) absence of appreciable intrinsic value tempting to the thief; (8) attractiveness.

Obviously some of these attributes are interrelated, such as initial cost, permanence, and maintenance cost. Low initial cost may not be economical in the long run if achieved by sacrificing long life. To keep public educational collections adequately labeled is at best difficult. If because of short life, early deterioration, or other shortcomings labels require frequent replacement, refurbishing, or other unduly time-consuming and costly attention, sooner or later the labeling of collections is likely to fall into disrepair. And because of the cost and time involved, restoring it to good order may suffer protracted delays. Many valuable collections have experienced these ups and downs in labeling. In the label designs to be discussed, initial cost has definitely not been the overriding consideration. Rather, low cost over the years and the optimum of desirable attributes in general have been the prime objectives.

Since the problem of the Morris Arboretum concerned mainly woody plants, the designs are primarily for trees and shrubs. However, some attention was devoted also to permanent greenhouse collections, special out-door plantings, and a variety of situations requiring appropriate adaptations. In all the labels the materials are the same—stainless steel and black locust wood *(Robinia pseudoacacia)*, one or the other or both being used in any given design as required. These materials were chosen because of proved long-lasting qualities. The designs of the labels are such that the wood can be replaced by metal or plastics if desired. In the absence of long successful experience with plastics out of doors, the Arboretum thus far has not used them.

Details of materials, fabrication, and equipment employed in producing the various types of labels will be furnished in a concluding appendix. But meanwhile the invaluable services of Mr. George Campbell of the Morris Arboretum are gratefully recorded. The successful development of fabricating methods and devices is largely the result of his ingenuity and skill. In addition, Mr. Campbell has contributed valuable features in the label designs.

The labels to be described are the following:

Tree trunk label with screw attachment.

Tree trunk label with expanding band attachment.

Hanging label for shrubs, small trees, woody vines, etc.

Removable standard label anchored in the ground for situations where plant-attached labels are not practical; also for special display collections.

Label for greenhouse, rock garden, bedding, etc., plants.

I. TREE TRUNK LABELING

The labels designed for tree trunks are of wood, and are of two types as regards mode of attachment. (1) For trees with sufficiently thick and firm cork (e.g., black walnut), screws penetrating the cork no deeper than the cork cambium fasten the label to the trunk (Fig. 14). (2) For trees with shallow cork (e.g., Fagus, Abies) or with loose shedding cork (e.g., some hickories), nothing is driven into the trunk; instead, label attachment is effected by means of a self-adjusting band encircling the trunk (Figs. 15 and 16).

These designs are the outgrowth of an attempt to bring into harmony the mode of at-

Fig. 14. Design of tree label attached to bark by screws anchored wholly in the cork. For details see Fig. 21.

tachment with the developmental anatomy of tree trunks. The well known difficulties experienced with tree labels (overgrowing of the label by the growing trunk; pushing over the heads of attaching screws or nails; initiation of decay; etc.) spring from a conflict between the mode of attachment and the growth habits and processes of the trunk. Since interest in tree labels is not confined to those thoroughly conversant with the precise nature of these processes, a brief review of the essential relevant facts of trunk growth may not be out of place.

A. Developmental Anatomy of Growing Tree Trunk

For our purposes the trunk falls naturally into the following main regions (Fig. 17): (1) the central cylinder of wood, surrounded by (2) the bark, with (3) the all-important cambium constituting the thin boundary between the first two.

By way of locating these three areas in everyday experience it may be recalled that when the bark is peeled from a trunk the separation usually occurs at or approximately at the cambium. The same discovery, albeit with more thrill, has been made by anyone who in mid spring has fashioned a whistle out of a willow, pawpaw, or other suitable twig. The gentle pounding of the peripheral bark of the twig is more than a ritual; it serves the essential purpose of crushing the very delicate newly formed tissues at the region of the cambium. As a result the entire central wood cylinder can be pushed out, leaving the bark intact as a hollow cylinder. Tempting as it is it would take us beyond our purpose to pursue further the gentle art of whistle making and virtuosity, including such fine points as raising and lowering the pitch by sliding the wood cylinder respectively toward or away from the fashioned "blow" end, reminiscent of a sliding trombone. But enough has been said to identify quite precisely in non-botanical terms what is bark, wood, and the location of the cambium.

The cambium, although completely encircling the wood cylinder, is minute in radial thickness.

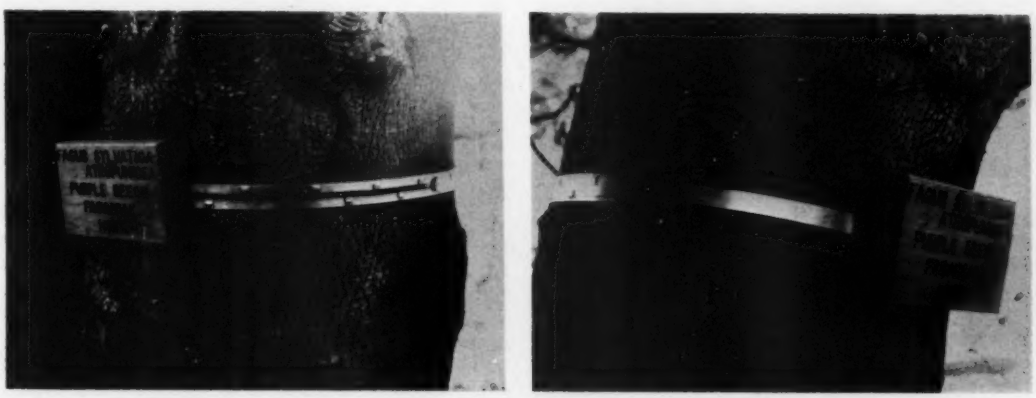

Fig. 15 and 16. Design of tree label attached to trunk by automatically expanding band. The photographs show respectively the two ends of the functioning band assembly. For details see Fig. 22.

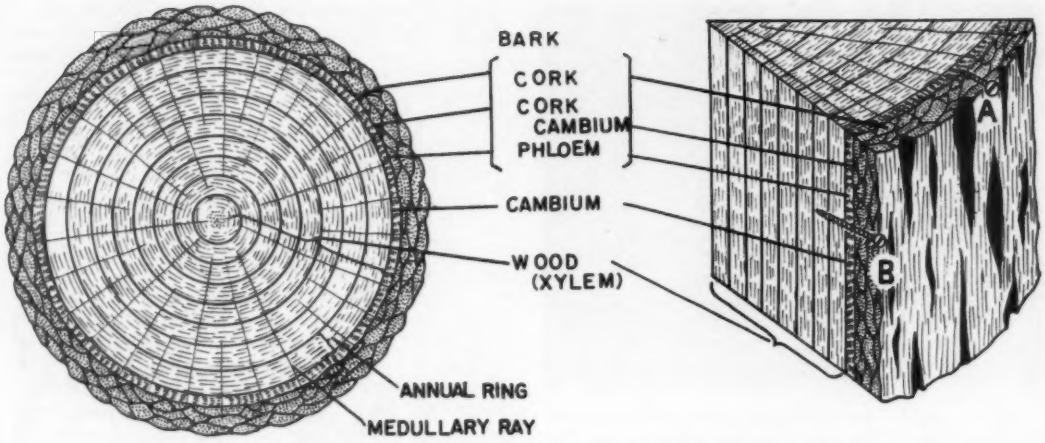

Fig. 17. Tree trunk eight years old showing schematically its three main regions: (1) The wood or xylem; (2) the bark, consisting of cork, cork cambium, and phloem; and (3) the cam bium. Left, a cross section in two-dimensional view; right, a pie slice in three-dimensional perspective.—*Drawing prepared by Dr. Hui-Lin Li, Research Associate of the Morris Arboretum.*

It may be envisioned as a microscopically thin and very delicate membranous tissue occupying precisely the boundary between the outer limits of the wood and the inner limits of the phloem (the latter the innermost region of the bark), with both of which it is at all times in the closest organic and living union. This position between wood and phloem is maintained throughout the life of the tree, whether the wood cylinder be a fraction of an inch in diameter or measured in yards as in a giant Sequoia. Thus, as the wood cylinder enlarges with growth the cambium moves out with it, constantly shifting its *absolute* position. But it never changes its *relative* position—always does it occupy the boundary between wood and phloem. To do this it obviously itself must and does grow tangentially, accommodating itself perfectly to the steadily increasing circumference.

The justification for dwelling on the cambium is that it is responsible for nearly all growth in thickness of the trunk, indeed of limbs, branches, twigs, and even of roots. In the growing season its minute cells divide tangentially, each into two cells — an outer and an inner. The inner ones (next to the wood) may speedily grow into typical wood cells, in which case the outer ones remain as cambium cells; or the outer ones may grow into characteristic phloem cells, in which instance the inner ones remain as cambium cells. This process repeats itself many times during the growing season. Thus the cambium generates on its inner face additional wood (strengthening and water-conducting tissue) and on its outer side additional phloem (conducting tissue for elaborated foods), but always the vital cambium persists at the boundary between the two. Obviously, the most recently formed wood is always at the *outermost* limit of the wood, whereas the newest phloem tissue is always at the *innermost* limit of the phloem.

Actually the volume of additional wood generated by the cambium in a growing season is much greater than the volume of new phloem produced in the same period. Moreover, the wood produced by the cambium early in the growing season is in many species conspicuously porous (large cells) whereas the wood generated toward the end of the growing season is denser (smaller thicker walled cells). Thus when wood production starts in the spring, there is an abrupt transition from the dense wood produced late in the previous season to the porous wood generated early in the current season. In this manner are produced the well known "annual rings" of wood so conspicuous in many of our trees.

For present purposes another growth process is important which meanwhile is taking place in the bark (Fig. 17). The outer portion of the bark consists of a substantial layer of protective cork. This, too, is formed by a cambium—the *cork cambium*—located at the inner limits of the cork. Dividing tangentially much as the cambium cells, the outer cells so formed are converted into cork cells, the inner ones perpetuating the cork cambium. (The cork cambium generates a little tissue also on its inner face; how-

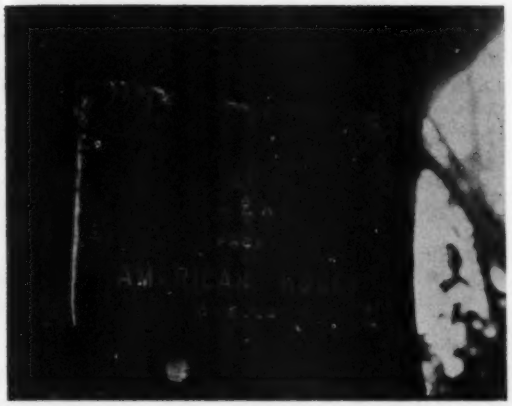

Fig. 18. Lead label, attached by a nail driven into the wood, in process of being pushed off over the large nail head.

ever, for present purposes it is unimportant and need not be traced further.)

Matured cork is a dead tissue. As such its cells cannot divide and grow to accommodate the cork to the constantly enlarging trunk circumference. In consequence the cork breaks in a great variety of ways, producing the surface bark configurations so characteristic of tree species:* deep vertical furrows and prominent firm ridges as in black walnut and tulip poplar, loose flaky scales as in apple and spruces, thin layers shed annually as in sycamore, vertical hanging plates as in shagbark hickories, etc., to mention only a few. Still other trees develop very little cork, the bark in consequence remaining thin and smooth with little or no shedding, as in beech, true firs, Carpinus.

With these facts in mind we return to the problem of attaching labels to trunks. Quite naturally the all but universal procedure is to drive screws or nails into the trunk, that is, through the bark and into the wood. This provides firm attachment, but it also invites trouble.

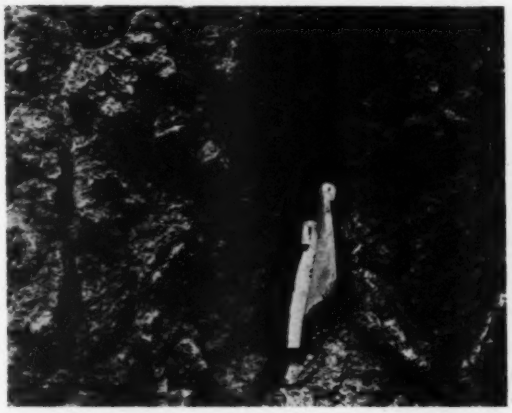

Fig. 20. Label attached by a nail driven into the wood. In this case the lead label was not pushed off over the nail head; instead, it was folded back on itself by the growing trunk and is in process of being swallowed up.

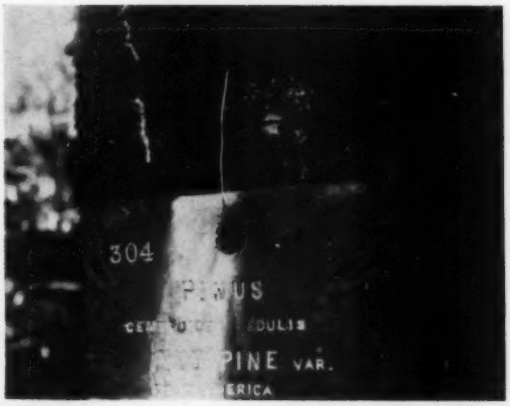

Fig. 19. Lead label pushed off over the head of its erstwhile attaching screw and fallen to the ground (resuspended for purposes of the photograph). The screw, anchored in the wood, all but completely engulfed by the bark.

A screw or nail so situated (Fig. 17 at B) is anchored at its far end in the wood. During the growing season the cambium adds new wood and new phloem in the manner already described. This new tissue interpolated by the cambium pushes the bark outward. But the nail or screw, being firmly anchored in the stationary wood, does not move outward with the bark but maintains its initial absolute position. In consequence the nail or screw is eventually completely overgrown. And meanwhile the label is either pushed off over the head (Figs. 18 and 19) or, failing this, is also engulfed (Fig. 20).

Various procedures are used in attempts to mitigate these difficulties, such as periodic outward adjustment of the nail or screw to keep ahead of the encroaching bark. The adjustments to be effective must be made regularly; unfortunately they may be difficult if not impractical to make. The newly developing tissues are molded so intimately and firmly about the nails or screws that the latter, even if not corroded, are likely to be "frozen."

*These configurations are determined by anatomical and developmental facts which need not be detailed here.

At the Morris Arboretum, too, decay has occasionally set in about nails and screws used in attaching labels. In some instances these have been very valuable—even unique—trees.

All in all, in restudying label design an attempt has been made to avoid the difficulties and hazards attending the traditional mode of attachment by screws and nails. Again referring to Fig. 17, a practical procedure at once suggests itself for trees with suitable bark which, although employing screws, avoids the above difficulties.

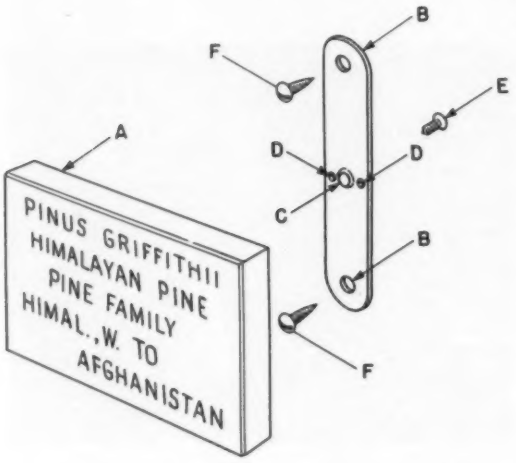

Fig. 21. "Exploded" view of trunk label design for attachment to the cork. A, inscription-bearing black locust wook block. To the right, the stainless steel attaching strip B: C, countersunk hole for attaching strip to block by screw E; D, D, countersunk holes, the projecting burs fixing the strip at the desired angle with reference to the block when screw E is tightened; B, holes for screws F, F, anchoring the assembly to the bark (screws do not penetrate beyond the cork).—*Drawing Courtesy H. L. Yoh Company, Inc., Philadelphia, Pa.*

The screw at A is anchored wholly in the cork. The cork being dead, the screw at no time enters living tissues, thus avoiding the hazard of initiating decay. But more important, the screw is never in danger of being overgrown. All the new tissues formed by the cambium and the cork cambium are laid down within the innermost anchoring point of the screw. In screw B, on the other hand, the new tissues are wedged in *between* the tip of the screw (anchored in the wood) on the one hand and the head on the other. Since the anchor in the wood holds firm, the screw keeps its initial *absolute* position and eventually is engulfed. Screw A, on the contrary, rides outward undisturbed as the trunk grows, constantly shifting its *relative* radial position while keeping its initial position in the dead cork.

It is apparent that only on tree trunks with sufficiently thick, firm, and non-shedding cork is it practical to employ the label designed for screw attachment (Fig. 14). For trunks with cork not meeting these specifications, the corresponding label design (Figs. 15 and 16) avoids screws and nails altogether and employs instead a self-adjusting band encircling the trunk. The band attachment can be used as well on all trees for which the screw attachment is practical. However, since the latter is simpler to fabricate and many species have suitable cork, the screw-attached design is widely used in the Arboretum and is therefore included in the general descriptions that follow.

B. Trunk Label With Screw Attachment (Fig. 21)

a. *The Wood Label.* — For most purposes a locust wood block 3″ x 5″ (¾″ or ⅞″ thick) is adequate; larger sizes can be used where necessary. The engraving is done with a power router in letters 5/16″ or 3/8″ high—large enough to be easily read though the label is attached well above arm's reach. Besides its phenomenal durability, locust wood has another important advantage. Being very hard, the high speed routing bit scorches the sides and bottom of the channel as it cuts. The result is a durable charcoal inscription requiring no tinting.

b. *The Stainless Steel Attaching Strip.* — To the back of the label a strip of steel is attached by a single centrally placed screw. This strip is so designed that within certain limits the label can be kept horizontal whatever the angle of the trunk or large limb to which it is attached.

c. *Fastening The Label To The Trunk.* — Attachment of the assembled label to a favorable cork ridge is effected by two screws of a length not penetrating beyond the cork. In some species with thin but very firm cork, e.g. red oak, ¼″ screws are holding well, though they are not recommended except in such very favorable cases. One naturally uses the longest screws that the cork will accommodate; however, it has not seemed necessary to exceed ¾″.

d. *Performance.* — Some hundreds of these screw labels have been in use for the past eight

to twelve years. During this period the labels on an occasional tree came loose because the nature of the cork was misjudged. In 1953 all were critically examined—the first systematic inspection since installation. In a few, slightly larger screws were substituted, the original ones having loosened (or rarely the labels were shifted to neighboring cork ridges). In other instances the screws, while firm in the cork, were tightened slightly. But the great majority required no adjustments whatever. A new type of screw has now been adopted (details in the appendix) which will reduce still further the number and frequency of adjustments.

In no case did the label itself show any deterioration. As expected on anatomical and developmental grounds, pushing off or overgrowth of labels was completely absent. And in no instance had decay been initiated in the tree. Using good judgment initially in selecting only trees having suitable cork, one such inspection in a minimum of five years should keep the screw labels in excellent order. For the hundreds of these labels in the Arboretum scattered over some 75 acres the inspection at the end of eight to twelve years of service required the time of one person for about two days. All adjustments were made on the spot. No label required replacement or other attention indoors, and it is expected that this will continue to be so for decades.

C. Trunk Label With Self-adjusting Band (Fig. 22)

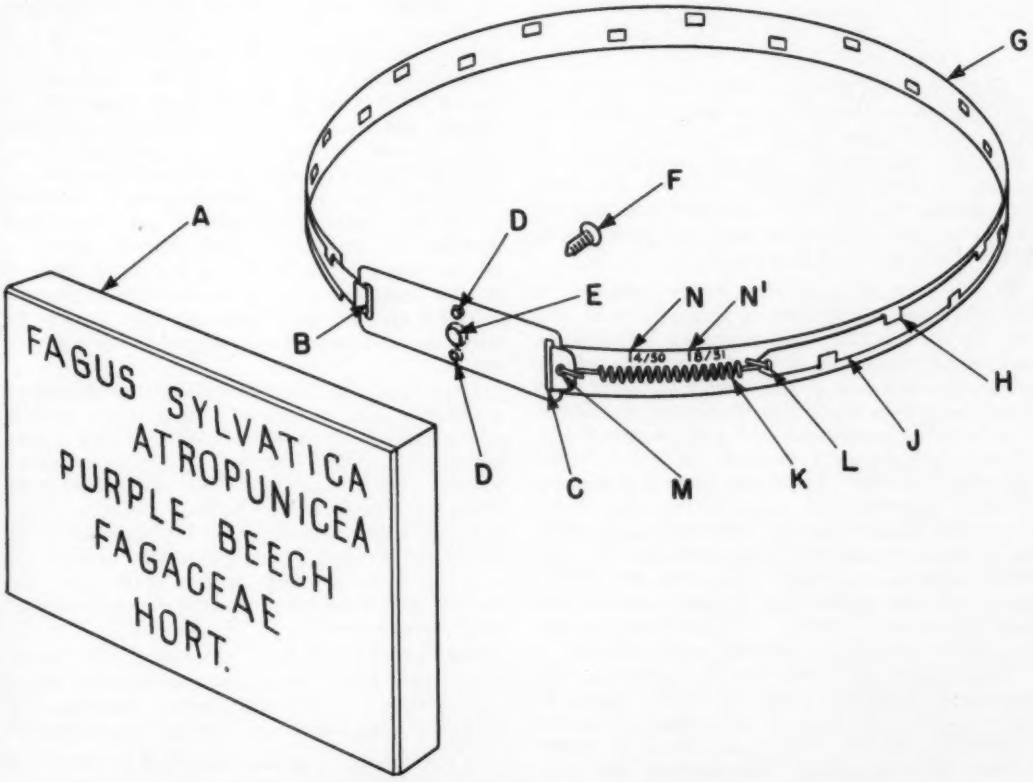

Fig. 22. "Exploded" view of tree label attached to trunk by self-adjusting band encircling the trunk. A, inscription-bearing black locust wood block. Just beyond, the stainless steel strip attached to the back of the block: E, countersunk hole through which screw F anchors the strip to the block; D, D, countersunk holes, the projecting burs fixing the strip at any desired angle with reference to the block when screw F is tightened (see Fig. 23); B and C, slots for anchoring ½" band J and ¾" band G respectively. H, staggered and opposing lugs in wider band G to form channel in which narrower band J slides. K, spring anchored in holes M and L, completing the assembly. Records at N and N¹ furnish growth data (for details see text). *Drawing Courtesy H. L. Yoh Company, Inc., Philadelphia, Pa.*

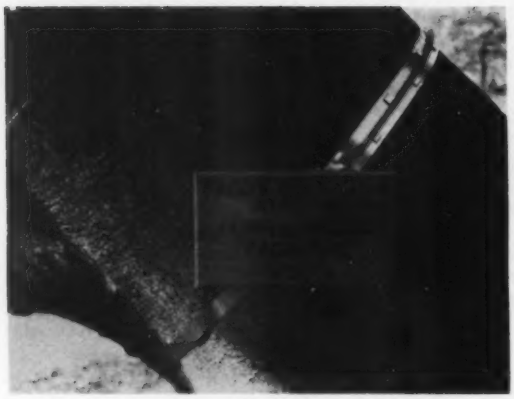

Fig. 23. Label firmly fixed in horizontal position whatever the angle of the trunk or limb to which expanding band is attached. For details see Fig. 22.

a. *The Wood Label.* — The wood label is in all respects indentical with the preceding, the difference in this design being wholly in the mode of attachment. Though developed originally for trees lacking bark suitable for screw attachment, it is practical on nearly all trees five inches or over in diameter and can therefore replace the screw label if desired.

b. *The Attaching Device.* — The principle of the attaching mechanism is apparent from Fig. 22. To the back of the wood block is fastened a steel strip, again by a single centrally placed screw. To one end is anchored a ½" steel band long enough to reach nearly around the trunk. To the other end is attached a ¾" band of sufficient length almost to encircle the trunk in the opposite direction. The wider band is prepunched with opposing and staggered lugs, forming a channel within which the narrower band slides. With the narrower band threaded under the lugs of the wider one, a length of stainless steel spring joins the two bands into a single system and puts the entire assembly under sufficient tension to hold it securely in position on the trunk.

As the trunk grows and exerts pressure on the encircling composite band, the latter adjusts itself automatically through the sliding of its two component bands, though always kept under tension by the spring. Throughout, the lugs keep the elongating spring in position on the midline of the wider band. And as the spring is extended more and more the tension increases, so that continued snugness of the encircling band is assured.

Even if it were practical on other grounds, which it is not, to achieve the same automatic adjustment by simply using a stainless steel spring encircling the trunk, it often would fail because of overgrowth. A spring lying directly on the bark exerts its entire pressure in the narrow line along which it touches the bark. This highly localized pressure, increasing as the spring is stretched, eventually stimulates the underlying living tissues, especially in thin-barked trees, to overgrow the offending spring. When, on the other hand, the spring lies on the steel band the same pressure is distributed evenly over the entire area under the encircling band. So distributed the pressure nowhere becomes sufficient to stimulate the slightest abnormal growth.

As a byproduct, the band device serves as a very fair dendrometer. The position of the free end of the narrower band is recorded by a vertical lead pencil mark on the wider band, adding the date and year (Fig. 22, N).* Annually thereafter, or at other desired intervals, the new position of the end of the narrower band is similarly recorded (Fig. 22, N^1,) the distance between the two being the circumferential growth during the interval. (If a forester's diameter tape is used, circumference measurements are read off directly in terms of diameter increment.) When bands are first attached to trees, conformity to the trunks is not perfect and some slack remains. Usually one year's growth takes up all this slack, after which movement of the end of the band is a measure of circumferential growth. In very slow growing trees it may be safer to wait two years before recordings are begun.

Lead pencil for these records is recommended advisedly. The surface of the stainless steel is microscopically pitted and takes pencil marks admirably. Based on 15 years' observation, weather is totally without effect on such records. However, they can be removed easily with an ordinary rubber eraser. This is not without significance, because outgrown bands can be reused on smaller trunks where again they can furnish dendrometric data free from confusion with earlier records.

One other secondary advantage the band-labeled tree has: it proclaims the welcome information that it is in fact labeled, whatever the direction from which the visitor approaches it.

c. *Performance.*—Some hundreds of the band labels have been in use for from 7 to 12 years. In the earliest ones the spring anchors were improperly designed and in some cases disengaged. With improved design no further such difficulty has been experienced. In three cases the bands failed to function after several years, and for

*If preferred, the position of the free end of the wider band can be recorded on the narrower band.

interesting reasons. In an Eastern White Pine, snow breakage several years after the label was installed necessitated removal of branch stubs above the level of the label. Resin poured from the wounds, running down the tree and over the bands. When the volatile matter had evaporated the bands were "frozen" in the solid residual rosin and unable to move. After a time trunk growth tore the wider band loose from its attachment. In a parallel case on a Norway Spruce badly diseased with Cytospora canker, copious resin exudation similarly resulted in "frozen" bands. In the third case (Cercidiphyllum) the band was so placed that at one point it lay in the upper acute angle made by a major branch with the trunk. When the bark of the enlarging branch made contact with the thickening trunk in this narrow angle, the band was caught in a vise. Aware of this possibility in certain species, it is easily avoided by properly locating the band.

Not until 1953 when the screw labels were inspected were all the band labels likewise critically examined. No other functional difficulties were found, and no deterioration either in the labels or the attachment mechanism was detected, nor does any seem in prospect. The only attention required — in a few rapidly growing trees — was the replacement of the outgrown bands (the component bands disengaged or about to be disengaged at their free ends by the growth of the trunk) with a new spring and band assembly of appropriate length. As in the screw labels, no sign of overgrowing or other induced abnormal growth was detected. And as would be expected from the mechanical principle of the band, no other injury of any kind had occurred.

(To be continued)